USING THE JUVENILE CLAM (*Mercenaria mercenaria*) BIOASSAY TO ASSESS THE EFFECTS OF SEDIMENT-ASSOCIATED CONTAMINANTS IN FLORIDA BAY

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Abstract

Previous research in our laboratory has shown that the juvenile clam, *Mercenaria mercenaria*, is sensitive to a variety of organic (DDT and fluoranthene) and inorganic (cadmium) contaminants in spiked-sediment bioassays. The goal of this study was to utilize this test organism to assess the potential ecotoxicological effects of sediment-associated contaminants in the South Florida C-111 canal system and Florida Bay. Clam bioassays were conducted in Revco® Environmental Chambers at 20 °C and 30 ppt salinity. Sediments were press-sieved through a 212-µm mesh screen. The sieved sediments (100 mL) were added to 600-mL beakers to which 300 mL of 20-µm filtered seawater were added. The sediment was allowed to settle under aeration for 24-h before the addition of fifty clams (> 212-µm and < 350-µm) per beaker. At the end of ten days, clam mortality was determined. Clam mortality was observed in sediments from several sites which contained significant levels of pesticides (endosulfan and p,p-DDE), metals (copper, mercury), and PAHs (naphthalene, 2-methylnaphthalene). These findings demonstrate the utility of the juvenile clam assay as a screening test for potential sediment toxicity.

Introduction

- Agricultural runoff in South Florida may pose an ecotoxicological risk to surrounding bay areas.
- The juvenile clam bioassay has been effective in assessing sediment-associated contaminant toxicity from sites in the Charleston Harbor estuary (Charleston, South Carolina).
- The objective of this research was to use the juvenile clam bioassay to assess the potential sediment toxicity in the C-111 canal and Florida Bay.

Figure 1. Juvenile *Mercenaria mercenaria*.

Material and Methods

Collection and Holding of *Mercenaria mercenaria*

- Juvenile clams of approximately the same size 212-350 -µm (retained on a 212-µm sieve) (Figure 1) were acquired from Atlantic Farm Inc. (commercial aquaculture facility located on James Island, SC) (Figure 2).
- Clams were sieved at the aquaculture facility to verify the size used for the bioassay.
- Seawater used for holding and exposures was collected from Bohicket Creek, a relatively uncontaminated tidal tributary of North Edisto River Estuary, SC.

Figure 2. Atlantic Farm Inc. (hatchery and phytoplankton culturing facility).

Field-Collected Sediment

- Sediment was collected from the C-111 canal system (1 site) and Florida Bay (4 sites) (Figure3)
- Folly River, a relatively uncontaminated site (Chung, 1999) located off the Stono River, Charleston, South Carolina, was used as the reference site.
- Sediment bioassay was conducted in pre-cleaned Pyrex 600-mL beakers
- Testing Conditions: 20°C, 30 ppt salinity, and a photoperiod of 12-h:12-h.
- Approximately 100 mL of sieved sediment was added into the beakers followed by 300 mL of 20-µm filtered seawater. Fifty clams were added into each beaker.
- Beakers were covered with solvent-rinsed foil and a 1-mm pipette was inserted for aeration.
- Water quality parameters (salinity, dissolved oxygen, pH, temperature) were taken daily.
- At the end of 10 days, the sediment was re-sieved to retrieve the clams and mortality was determined from each beaker and recorded.
- Clams were deemed dead if the shell was gaping or if movement was not detected under microscope after five minutes.
- Data Analysis - ANOVA was to used to determine if significant group differences existed. Scheffe's multiple comparison test was used to determine significant differences among the sites.

Analytical Chemistry

- Sediment was analyzed for trace metals (Al, As, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, Sn, Zn) (AA, ICP), persistent organic pesticides (17 analytes with endosulfan consisting of alpha, beta, sulfate, lactone, and ether isomers) (GC-ECD), and polycyclic aromatic hydrocarbons (17 PAHs) (GC-MS) following NS&T Program protocols (Fortner et al.,1996; Kucklick et al., 1997; Sanders, 1995).

Results

Table 1. Polycyclic Aromatic Hydrocarbon (PAH) Concentrations (ng/g = ppb) detected in sample sites.

Site	Phenanthrene		Fluranthene	Benzo(a)anthracene		Perylene	Benzo(k)fluoranthene		Pyrene	Benzo(ghi)perylene		2-methylnapthalene
	Fluorene	Anthracene	Dib(a,h)anthracene		Chrysene		Benzo(b)fluoranthene	Benzo(e)pyrene		Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Naphthalene
Joe Bay	<6.10	7.86	<7.58	<9.32	<3.55	<16.7	<4.76	<12.3	<12.9	<11.1	<9.79	<6.84	<21.2	<13.3	<20.6	45.4	41.3
Little Madeira Bay	<6.16	<7.38	<7.65	<9.41	<3.59	<16.8	<4.80	<12.5	<13.1	<11.2	<9.88	<6.90	<21.4	<13.4	<20.8	396*^	344*
Station C	<7.79	15.9	<9.67	<11.9	<4.54	<21.3	<6.08	33.3	<16.5	<14.1	<12.5	13.4	<27.1	<17.0	<26.3	56.7	74.2
Station H	<3.88	37.9	7.2	179	<2.26	63.5	136	14.6	107	39	47.4	151	56.8	31	41.4	25.1	32.6
Station I	<8.44	10.8	<10.5	<12.9	<4.92	<23.1	<6.59	<17.1	<17.9	<15.3	<13.5	10.2	<29.3	<18.4	<28.5	67.5	84.4
Folly River	3.99	11.1	4.99	43.9	4.38	33	29.6	11.8	48.4	19.4	23.6	36.1	31.1	17.7	21.9	44.3	41.7

- Values in red exceeded the TEL value (*denotes ERL exceedance and ^ denotes PEL exceedance)

Table 3. Pesticide Concentrations (ng/g = ppb) detected in sample sites.

Site	o,p'-DDD	o,p'-DDE	o,p'-DDT	p,p'-DDD	p,p'-DDE	p,p'-DDT	Aldrin	α-Chlordane	Dieldrin	Lindane	Heptachlor	Heptachlor Epoxide	HCB	Mirex	trans-Nonachlor	Endosulfan	Chlorpyrifos
Joe Bay	<0.061	<0.058	<0.144	<0.243	<0.033	<0.016	<0.013	<0.082	<0.181	<0.076	<0.040	<0.102	<0.062	<0.157	<0.094	1.33	<0.100
Little Madeira Bay	<0.061	<0.058	<0.144	<0.243	<0.033	<0.016	<0.013	<0.082	<0.181	<0.076	0.182	<0.102	<0.062	<0.157	<0.094	0.36	<0.100
Station C	<0.061	0.5	0.73	<0.243	113	2.53	<0.013	1.44	0.668	<0.076	<0.040	<0.102	<0.062	<0.157	1.51	169	<0.100
Station H	<0.061	<0.058	<0.144	<0.243	<0.033	<0.016	<0.013	<0.082	<0.181	<0.076	0.093	<0.102	<0.062	<0.157	<0.094	<0.100	<0.100
Station I	<0.061	<0.058	<0.144	<0.243	<0.033	<0.016	<0.013	<0.082	<0.181	<0.076	0.315	<0.102	<0.062	<0.157	<0.094	<0.100	<0.100
Folly River	<0.061	<0.058	<0.144	<0.243	0.57	<0.016	<0.013	<0.082	<0.181	<0.076	<0.040	<0.102	<0.062	<0.157	<0.094	N/M	N/M

- Values in blue exceeded ERM value (3.74 ng/g) and pink exceeded the ERL value (0.5 ng/g) (NOAA 1990)

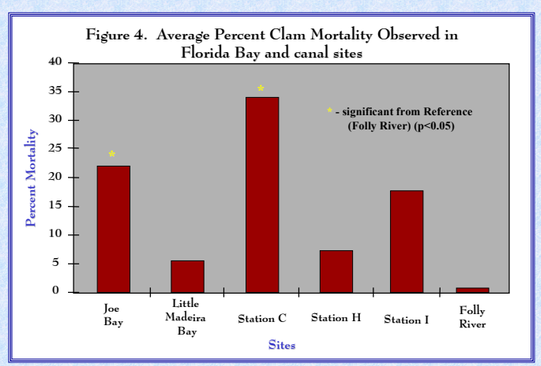
Site C - 2 TEL exceedances for PAHs, 2 TEL and ERL exceedances for metals, ERL exceedance for α-chlordane (1.44 ng/g) and ERM for p,p-DDE (113 ng/g), and total endosulfan concentrations of 169 ng/g
Joe Bay - 2 TEL exceedances for PAHs, 1 TEL and ERL exceedance for metals, total endosulfan concentration of 1.33 ng/g
Site I - 2 TEL exceedances for PAHs
Site H - 3 TEL exceedances for PAHs
Little Madeira Bay - 2 TEL exceedances for PAHs and one ERL exceedance for PAHs, total endosulfan concentrations of 0.36 ng/g
Folly River - 2 TEL exceedances for PAHs

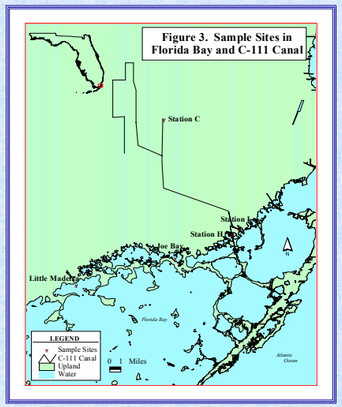
Table 2. Metal Concentrations (µg/g = ppm) detected in sample sites.

Site	Al (%)	As (µg/g)	Cd (µg/g)	Cr (µg/g)	Cu (µg/g)	Fe (%)	Pb (µg/g)	Mn (%)	Hg (µg/g)	Ni (µg/g)	Se (µg/g)	Ag (µg/g)	Sn (µg/g)	Zn (µg/g)
Joe Bay	0.93	10.20	<0.031	22.30	0.91	1.05	4.86	65.00	0.10	5.98	<0.030	<0.019	15.70	13.70
Little Madiera Bay	0.40	0.89	0.07	11.00	<0.542	0.49	3.38	49.60	0.07	3.62	<0.030	<0.018	16.10	7.86
Station C	2.66	0.65	0.41	58.10	71.20	1.11	23.10	133.00	0.23	14.90	<0.033	0.10	13.10	83.70
Station H	0.23	0.65	<0.025	6.22	3.33	0.22	5.82	35.00	0.04	<2.75	<0.024	<0.015	12.90	6.30
Station I	0.28	3.08	0.05	8.71	19.00	0.46	12.30	39.30	0.11	<3.38	<0.03	<0.018	11.60	27.40
Folly River	1.33	6.86	<0.034	19.80	3.03	1.20	7.08	98.40	<0.017	4.20	0.31	<0.020	10.80	23.70

- Values in blue exceeded TEL (Threshold Effects Level) and ERL (Effects Range Low) values

Sediment Quality Guidelines (TEL/PEL - MacDonald 1994; ERL/ERM - NOAA 1990, Long et al., 1995) were used to assess potential bio-effects from sediment-associated contaminants.





Conclusion

- The two sites (Station C and Joe Bay) that had significant depressed survival relative to the reference (Folly River) also had measurable concentrations of endosulfan.
- Station C (highest clam mortality) had high sediment concentrations of endosulfan, copper, mercury, naphthalene, 2-methylnaphthalene, p,p-DDE, and α-chlordane.
- Joe Bay - levels of As, 2-methylnaphthalene and naphthalene exceeded the TEL and ERL values.
- The clam assay is a useful tool in ecotoxicological risk assessment.

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